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EFFECT OF PRE-HARVEST SPRAY OF CALCIUM AND BORON ON YIELD AND QUALITY ATTRIBUTES OF APPLE CV. RED DELICIOUS

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ABSTRACT
The present study was aimed to assess the effect of different levels of calcium chloride and boric acid on fruit quality of apple. The chemicals used as pre-harvest spray were $CaCl_2$ (0.0, 0.1, 0.2, 0.4%) and H_3BO_3 (0.0, 0.5, 0.15, 0.25 %) sprayed twice at fifteen days interval commenced from the first week of July. The highest fruit weight of 163.36g and 161.15g was recorded with combined application of calcium chloride (0.1%) and boric acid (0.15%) during first and second year respectively. A stimulating effect on the development of fruit colour was observed with the use of calcium chloride and boric acid. Highest mean yield of apple fruit184.57kg /tree and 163.23kg /tree was obtained with combined application of calcium chloride and boric acid during the two years of study. The interaction effect of Calcium chloride (0.2%) and boric acid (0.15%) resulted in the highest vitamin C content. The main effect of calcium chloride at 0.2% registered maximum pH. However, the lowest pH of 3.85 and 3.81 was observed under control. The study revealed that calcium chloride in combination with boric acid increased yield of apple fruit besides quality parameters in comparison to control during both the years.

INTRODUCTION

Apple *Malus* × *domestica* Borkh a typical temperate fruit is thought to have originated in the region which includes Caucasus, Soviet Central Asia, Himalayan India and Pakistan. It belongs to the family Rosacea and sub family pomoideae. Fruit culture being an important industry in the economy of Jammu & Kashmir state and due to multi pronged approach, the production of apple culminated to 11,39,180 metric tons with an area of 1,44,733 ha. (Anonymous, 2014). Apple tree like other pome fruits needs calcium and boron to achieve proper growth and fruiting. In addition, storing stability depends upon the content of distinct mineral nutrients such as calcium and boron. Thus high availability of nutrients during fruit formation is required. Application of micro and macro nutrients promoted fruiting quality and substantially increased the average fruit weight and yield of apple and grape (Kumar *et. al.,* 2003; Marzouk and Kaseem,2011). In an experiment with apple calcium spray improved fruit quality a measured by an increase in fruit colour development of skin (Raese and Drake,2000). Recently plant nutrient studies have focused attention upon significance of calcium and boron, particularly in apple where it can influence various enzymatic and physiological processes. Calcium has been reported to extend the shelf life of fruit by maintaining structural integrity, minimizing respiration, proteolysis, disease incidence and tissue breakdown and thus reducing the per cent loss in weight. It act as anti -senescent agent (Scott and Wills, 1975). Boron plays a significant role in improving fruit set, their retention at maturity and quality. Phenomenal increase in productivity has been achieved in many fruit crops where specific nutrients are applied as foliar spray. Several workers have claimed significant improvement in the yields and quality of fruit crops following calcium and boron spray. (Mehta and Jindal 1984; Mir *et. al.,* 1996). During the past two decades apple orchards exhibited the deficiency of calcium and boron that resulted in poor quality of produce. Furthermore, there has been a little local consideration of calcium and boron nutrition in apple orchards. Therefore, the present investigation was undertaken to gain more insight and elicit the role of pre-harvest calcium and boron spray on growth and quality parameters of apple.

MATERIALS AND METHODS

The experiment was carried out on uniform twenty year old trees of apple cv. Red Delicious during two consecutive years of 2003 and 2004 at Experimental Farm, Division of Pomology SKUST-K, Shalimar. The chemicals used as pre-harvest spray were calcium chloride (0.0, 0.1,0.2 and 0.4%) and boric acid (0.0,0.05,0.15,0.25%). All the tress received uniform cultural practices during the whole period of investigation. The trees were sprayed twice in the first and second week of July. A single tree was considered as an experimental unit and the chemicals were sprayed using Tween-20 as surfactant. The experiment was laid out in 4×4 factorial Randomized Block Design with three replications. Fruits were harvested at maturity as per the standard procedure and the fruits of uniform size free from pests, diseases and blemishes were randomly selected in each replication of all the treatments for recording observation (Waller,1980). Fruit production characters like fruit weight and fruit yield were recorded as per the procedures

suggested by Westwood, 1993. Individual fruits were scored for colour of the skin on the basis of 1-4 scale (Blenpied *et al.*, 1975). Ascorbic acid content was determined by titrating freshly extracted juice against 2,6 dichlorophenol indophenol dye (Rangana,1986).The pH of the sample was recorded with help of digital pH meter 'Tanco DD-1011'.

RESULTS AND DISCUSSION

Main effect of calcium chloride and boric acid was highly significant as far as fruit weight was concerned during 2003 and 2004 (Table 1). The highest fruit weight of 163.36 g and 161.15 g was recorded when trees received combined spray of 0.1% calcium chloride with 0.15% boric acid during first and second year respectively. The lowest fruit weight of 121.45g and 120.13 g was observed under control during 2003 and 2004. Striking effect of calcium and boron in enhancement of fruit weight has been widely established (Mehta and Jindal, 1984; Mir *et al.,* 1996 and Kumar *et al.,* 2003). The increase may be due to enhanced synthesis of metabolites, increased absorption of water and mobilization of sugars and minerals in the expanded cells and intercellular spaces. Boron either singly or in combination also helped in maximum increase in fruit weight by accelerating the transportation of photosynthates from leaf to the developing fruit (Dugger,1983). Calcium is required for cell elongation and cell division. There is now evidence that auxin induced H^+ secretion of meristematic cells is related to the presence of Ca^{+2} (Marme,1983).

A stimulating effect on development of fruit colour was observed with the use of calcium chloride and boric acid as pre-harvest spray (Table 2). Spraying with calcium chloride yielded comparatively better coloured fruits than control. Similarly, trees which received boric acid resulted in superior red coloured fruits compared to untreated control. Fruit trees sprayed with calcium and boron resulted in better coloured fruits of apple cv. Red Delicious (Bhat and Farooqui, 2004) . As boron helped in translocation of sugars (Davenport and Peryea,1990) so high level of carbohydrate might have increased the anthocyanin pigment and thus resulted in an increased colour development. Moreover high calcium can effectively counter act the detrimental metabolic effect of high nitrogen (Shear and Faust,1975) and colour development may be a attendant physiological manifestation of this relationship.

Highest mean yield of 170.43kg/tree and 155.47 kg /tree was recorded with 0.15% boric acid during first and second year respectively. Among various chemical treatment combinations calcium chloride at 0.1% plus boric acid at 0.15% resulted in the highest fruit yield of 184.57kg/tree and 163.23 kg/tree during 2003 and 2004 (Table 3). The lowest fruit yield was observed with water spray during both the years of study. The

Table 1: Effect of calcium chloride and boric acid on fruit weight (g) of apple cv. Red Delicious

Calcium chloride concentration(%)	2003 Boric acid concentration (%) B0	B1	B2	B3	Mean	2004 Boric acid concentration (%) B0	B1	B2	B3	Mean
C0	121.45	152.86	133.75	143.57	137.91	120.13	152.56	136.80	142.38	137.97
C1	149.93	159.31	163.36	147.51	155.03	152.16	160.51	161.15	147.72	155.38
C2	125.91	159.16	162.02	135.19	145.57	127.24	160.11	160.60	126.35	143.57
C3	128.41	153.60	154.48	123.45	139.98	133.89	153.51	153.63	125.77	141.70
Mean	131.42	156.23	153.40	137.43		133.35	156.67	153.04	135.55	

CD: (p = 0.05); Calcium chloride (C) : 1.62 1.74; Boric acid (B) : 1.62 1.74; C × B Interaction : 3.25 3.49

Table 2: Effect of calcium chloride and boric acid on fruit Colour (Score) of apple cv. Red Delicious

Calcium chloride concentration(%)	2003 Boric acid concentration (%) B0	B1	B2	B3	Mean	2004 Boric acid concentration (%) B0	B1	B2	B3	Mean
C0	2.31	2.42	3.26	2.52	2.62	2.30	2.38	3.28	2.48	2.61
C1	2.35	2.63	3.33	3.16	2.87	2.35	2.55	3.34	3.13	2.84
C2	3.10	2.87	3.49	3.20	3.16	2.94	2.88	3.54	3.22	3.15
C3	2.46	2.81	3.41	3.22	2.98	2.43	2.68	3.46	3.24	2.95
Mean	2.56	2.68	3.37	3.02		2.50	2.62	3.41	3.01	

CD: (p = 0.05); Calcium chloride (C) : 0.01 0.01; Boric acid (B) : 0.01 0.01; C × B Interaction : 0.02 0.03

Table 3: Effect of calcium chloride and boric acid on fruit yield (kg/tree) of apple cv. Red Delicious

Calcium chloride concentration(%)	2003 Boric acid concentration (%) B0	B1	B2	B3	Mean	2004 Boric acid concentration (%) B0	B1	B2	B3	Mean
C0	146.52	162.92	155.78	157.18	155.60	121.20	151.31	143.71	147.29	140.88
C1	159.03	172.44	184.57	158.87	168.72	150.08	158.24	163.23	148.94	155.12
C2	152.81	169.69	175.81	156.18	163.62	129.85	154.30	158.94	144.79	146.97
C3	155.38	165.24	165.57	149.24	158.86	143.91	152.22	155.99	141.99	148.53
Mean	153.43	167.57	170.43	155.36		136.26	154.02	155.47	145.75	

CD: (p = 0.05); Calcium chloride (C) : 3.06 1.66; Boric acid (B) : 3.06 1.66; CXB Interaction : 6.12 3.33

Table 4: Effect of calcium chloride and boric acid on pH of apple cv. Red Delicious

Calcium chloride concentration(%)	2003 Boric acid concentration (%)				Mean	2004 Boric acid concentration (%)				Mean
	B0	B1	B2	B3		B0	B1	B2	B3	
C0	3.85	3.88	3.83	3.93	3.87	3.81	3.93	3.85	3.88	3.87
C1	3.86	4.06	4.09	3.87	3.97	3.94	4.13	4.11	3.93	4.03
C2	4.17	4.11	4.14	3.96	4.09	4.15	4.09	4.15	3.89	4.07
C3	4.15	4.12	3.96	3.93	4.04	4.15	4.15	3.89	3.90	4.02
Mean	4.01	4.04	4.00	3.92		4.01	4.07	4.00	3.90	

CD: (p = 0.05): Calcium chloride (C) : 0.01 0.01; Boric acid (B) : 0.01 0.01; C × B Interaction : 0.02 0.03

Table 5: Effect of calcium chloride and boric acid on vitamin C (mg/100g) of apple cv. Red Delicious

Calcium chloride concentration(%)	2003 Boric acid concentration (%)				Mean	2004 Boric acid concentration (%)				Mean
	B0	B1	B2	B3		B0	B1	B2	B3	
C0	4.94	5.15	8.17	5.35	5.90	4.47	4.89	7.80	5.20	5.59
C1	5.15	5.56	8.37	7.54	6.65	4.83	5.30	8.42	6.81	6.34
C2	7.41	6.18	8.64	7.75	7.49	6.55	5.46	8.69	7.44	7.03
C3	5.30	5.77	8.42	8.01	6.87	4.94	5.93	8.63	7.80	6.82
Mean	5.70	5.66	8.40	7.16		5.20	5.39	8.39	6.81	

CD: (p = 0.05); Calcium chloride (C) : 0. 34 0.29; Boric acid (B) : 0.34 0.29; C × B Interaction : 0.68 0.59

higher yield in apple was recorded with the combined application of calcium chloride and boric acid and it is established that a positive correlation exists between boron and tree vigour (Azad ,1999) . Improved yield has been also reported with the foliar spray of boron in apple (Shorrocks *et al.*,1980). Application of nutrients as pre-harvest spray showed an increased 150g and 91g of fruit weight plus yield of 28.50kg/tree and 22.50kg/tree with boron and calcium respectively (Jitendra *et al.,* 2015). Vitamin C content of the fruits increased with the application of calcium and boron spray (Table 4). An appreciable increase in Vitamin C content of 8.64mg/100g and 8.69mg /100g was recorded in the fruits that received calcium chloride @ 0.2% and boric acid @ 0.15% in the first and second year. The lowest vitamin C content of 4.94mg/100g and 4.47mg/100g was recorded under control during first and second year respectively. Ascorbic acid content in the fruits of apple, pear and tomato increased by increasing their calcium content during the growing season or even by post harvest application (Bangerth,1976). The higher ascorbic acid content (vitamin C) levels may be attributed to hexose sugars via photosynthetic activity (Sharma ,1984).

Calcium chloride and boric acid significantly influenced the pH of the fruit (Table 5). Calcium chloride at 0.2% registered maximum pH (4.09) during the year 2003. Similarly, maximum pH was observed with intermediate level of calcium chloride during the following year. The lowest pH value of 3.85 and 3.81 was observed when none of the chemical was sprayed during both the years. The maximum value of pH was obtained with the combined application of calcium chloride and boric acid during the two years. Fruits treated with 1.0% calcium chloride effected the tritable acidity and improved overall acceptability of fruit (Vandana *et.al.,*2015). Free weak acids associated in the cell constitute buffer system which play an important role in the cell, particularly in relation to the proteins of the cell especially in enzymes. The buffer ratio changes with the fruit growth (Amerine and Winkler, 1958). The beneficial effect of exogenous application of calcium and boron on different fruits were reported by many researchers in fruit crops viz., apple (Pant and Tewari,1987; Gyul- akhmedov and Gasanova,1999), Cherry (Bhat *et al.,* 1997) and grapevine (Marzouk and Kaseem, 2011).

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